

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
4 September 2003 (04.09.2003)

PCT

(10) International Publication Number
WO 2003/073481 A3

(51) International Patent Classification⁷: G01N 23/225, 23/203, H01L 21/66

(21) International Application Number:
PCT/US2003/007264

(22) International Filing Date: 24 February 2003 (24.02.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/359,222 22 February 2002 (22.02.2002) US

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

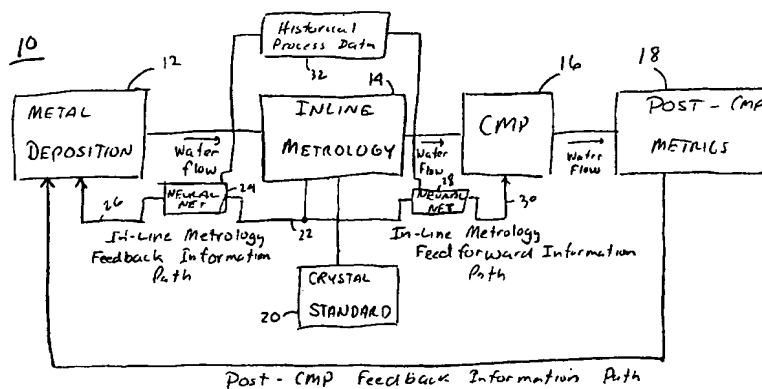
Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(88) Date of publication of the international search report:
3 June 2004

[Continued on next page]

(54) Title: FEEDFORWARD AND FEEDBACK CONTROL OF SEMICONDUCTOR FABRICATION PROCESS USING SECONDARY ELECTRON MICROSCOPY AND A FOCUSED ION BEAM SYSTEM



(57) Abstract: A system (70) for crystallography including a sample holder (74), an electron source (76) for generating an electron beam, and a scanning actuator (80) for controlling the relative movement between the electron beam and the crystalline sample, the scanning actuator being controllable for directing the electron beam at a series of spaced apart points within the sample area. The system also includes an image processor (84) for generating crystallographic data based upon electron diffraction from the crystalline sample and for determining whether sufficient data have been acquired to characterize the sample area. The system further includes a controller (86) for controlling the scanning actuator to space the points apart such that acquired data is representative of a different grains within the crystalline sample. In other embodiments, the invention includes one or more ion beams (178, 188) for crystallography and a combination ion beam/electron beam (218, 228). Crystallographic metrology data may be grain size and orientation which are feedback and feed-forwarded to a deposition station (such as a CVD station) and to a chemical-mechanical planarization station respectively for in-line control of the fabrication process of a semiconductor.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/07264

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N23/225 G01N23/203 H01L21/66

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 466 934 A (ADAMS BRENT L ET AL) 14 November 1995 (1995-11-14) column 2, line 66 - column 8, line 8	1-3, 7, 30-32, 37 6, 36
Y	-----	
X	US 5 557 104 A (FIELD DAVID P ET AL) 17 September 1996 (1996-09-17) column 2, line 66 - column 6, line 51	1-3, 30-32
X	MCINTOSH J: "Using CD-SEM metrology in the manufacture of semiconductors" JOM, MARCH 1999, MINERALS, METALS & MATER. SOC, USA, vol. 51, no. 3, March 1999 (1999-03), pages 38-39, XP001153203 ISSN: 1047-4838 page 38	1, 4, 5, 30, 33-35
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

4 November 2003

Date of mailing of the international search report

02.04.2004

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INTERNATIONAL SEARCH REPORT

Interr ... Application No

PCT/US 03/07264

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EL CHEMALI C AND AL: "Multizone uniformity control of a chemical mechanical polishing process utilizing a pre- and postmeasurement strategy" JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART A, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 18, no. 4, pt 1-2, July 2000 (2000-07), pages 1287-1296, XP002217674 ISSN: 0734-2101 page 1289</p>	4,5
A	<p>BENNETT M H ET AL: "IN-PROCESS INSPECTION AND METROLOGY OF SEMICONDUCTOR WAFERS WITH THE USE OF AN AUTOMATED LOW-VOLTAGE SEM" MICROBEAM ANALYSIS, SAN FRANCISCO PRESS INC., SAN FRANCISCO, CA, US, 1986, pages 649-652, XP000567217 ISSN: 1061-3420 page 649</p>	4,5
A	<p>US 6 298 470 B1 (BREINER LYLE ET AL) 2 October 2001 (2001-10-02) column 6, line 44 - column 7, line 38</p>	4,5
Y	<p>BARR D L ET AL: "MICROTEXTURE MEASUREMENTS OF ALUMINUM VLSI METALLIZATION" MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS, MATERIALS RESEARCH SOCIETY, PITTSBURG, PA, US, vol. 391, 17 April 1995 (1995-04-17), pages 347-352, XP000992306 ISSN: 0272-9172 page 347 - page 348; figure 1</p>	6,36
A	<p>EP 0 727 659 A (SEIKO INSTR INC ;MITSUBISHI ELECTRIC CORP (JP)) 21 August 1996 (1996-08-21) column 1</p>	7,37

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 03/07264

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-7, 30-37

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 03/07264

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7,30-37

Scanning electron microscope (SEM) adapted to generate crystallographic data from different grains within the crystalline sample; method of using the apparatus.

2. claims: 8-14,38-49

Focused ion beam (FIB) apparatus adapted to provide a contrast image; method of using the apparatus.

3. claims: 15-22,50-60

Combined SEM and FIB apparatus adapted to provide a contrast image and crystallographic data from different grains within the sample; method of using the apparatus.

4. claims: 23-29

Crystallographic standard sample for ion channeling analysis of a crystalline sample.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/07264

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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